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PROVISIONAL SPECIFICATION

Invention Title: **ELECTRIC BRAKE ACTUATOR ASSEMBLY**

Applicant: **PBR AUSTRALIA PTY LTD**

The invention is described in the following statement:

ELECTRIC BRAKE ACTUATOR ASSEMBLY

The present invention relates to an electric brake actuator assembly for actuating the brakes of an automotive vehicle. The present invention has been developed principally for use with the parking brakes of a vehicle and it will be convenient to describe the invention in relation to that application. However it is to be appreciated that the invention could have wider application, say to the service brakes of a vehicle and therefore is not to be understood as being limited in use to the application as hereinafter described.

Parking brake assemblies for automotive vehicles typically are applied at each pair of parking wheels of the vehicle. The assemblies may be cable actuated and if so, an actuating cable is connected to each assembly, and a pull load applied to the cables is operable to apply the brake assemblies and brake the vehicle. In a manually operated parking brake system, the pair of cables can be connected by a single cable to a lever disposed within the vehicle cabin adjacent the vehicle driver and the driver applies the parking brakes by actuating the lever manually to apply a pull load to the single cable, which transmits that pull load to the pair of cables connected to the brake assemblies.

In an electrically actuated parking brake system, the single cable and lever are not required, but rather an electric system, which may be push button operated by the vehicle driver, can be employed. The system sends an electric signal upon depression of the push button to the electric actuator, which is operable to apply a pull load to each of the cables connected to the parking brake assemblies for application of the parking brakes.

In each of the above arrangements, for proper operation of the parking brakes, sufficient cable pull or travel must be applied to each of the pair of cables for the brake shoes of each brake assembly to properly engage the braking surface and thereby to properly brake the vehicle. Generally, the cable travel required will be equal for each cable, but under some circumstances, unequal travel will be necessary say for example, if the friction lining of one of the brake shoes of one of the brake assemblies has worn more than the brake shoe of the other brake assembly. It can also be necessary if one of the pair of cables stretches more than the other cable, or if the length of one is slightly greater than the other, or if the tolerance stack in the mechanism is greater in

the assembly on one side of the actuator than the other, or if there is an imbalance in the initial adjustment of the brake shoe clearance.

In the above circumstances, equal cable travel will result in one of the pair of brake assemblies being applied to a lesser extent than the other, so that in extreme circumstances the parking brakes will not hold the vehicle stationary, because one of the wheels will not be properly braked.

The present invention is concerned with electric brake actuator assemblies, rather than the manual assemblies discussed above and it is an object of the present invention to provide an electric brake actuator assembly, which overcomes or at least alleviates problems or drawbacks associated with the prior art. It is a further object of the present invention to provide an electric brake actuator assembly having a mounting arrangement which facilitates equalisation of the load applied to the brake assemblies, by permitting a difference in the cable travel applied to the respective cables of each brake assembly.

An electric brake actuator assembly according to the present invention includes an electric actuator which cooperates with a pair of cables that extend respectively to brake assemblies associated with the wheels of a vehicle and which is operable to pull the cables to apply the brake assemblies, the assembly including a mounting arrangement which permits movement of the electric actuator away from a second of the brake assemblies in circumstances when the cable pull applied by the actuator is operable to properly apply the first of the brake assemblies only and whereby away movement of the actuator applies further travel to the cable associated with the second brake assembly for proper application of that assembly.

The invention is particularly suited for use with an electric actuator of the rotary type, which includes a rotary member to which a pair of cables are connected, or extend from opposite sides of the axis of rotation of that member. In such an actuator, rotation of the rotary member in one direction pulls the cables in opposite directions and for travel away from the respective brake assemblies to actuate each assembly and the arrangement typically is such that the cables will travel an equal amount as the rotary member rotates. As discussed above, in circumstances where only one of the brake assemblies is properly applied by equal cable travel, then shifting movement of the electric

actuator can facilitate proper application of the other brake assembly. Such shifting movement is required, because further rotation of the rotary member will not be possible if one of the brake assemblies is properly applied, because the brake shoe of that assembly will have firmly engaged the braking surface. Further cable travel away from the brake assembly will not be possible because that would require further movement of the brake shoe. However, if the actuator shifts away from the second brake assembly and therefore toward the first brake assembly, the cable associated with the second brake assembly can be pulled further. Additionally because the actuator shifts towards the first brake assembly, the rotary member of the actuator will be able to further rotate to maintain the load in the cable of the first brake assembly and each of the shift and the further rotation can continue until sufficient cable travel has occurred for the second brake assembly to be properly applied. Thus, the cable associated with the second brake assembly is pulled a further distance by the displacement of the actuator, while the load on the cable of the first brake assembly is maintained by further rotation of the rotary member.

Other forms of actuator can also be employed in the assembly of the invention. For example, the actuator may be one which is arranged for cooperation with a single continuous cable connected to each of the brake assemblies, so that there is no cable end connection to the actuator, but rather the cable is threaded through or about the actuator. Other forms of electric actuator may be equally applicable.

In one form of the invention, the electric actuator is mounted for linear shifting movement, such as sliding movement, whereby the mounting arrangement includes a mounting arm or track on which the actuator is mounted for movement as required. In a further form of the invention, the electric actuator is mounted for pivoting movement, whereby the mounting arrangement includes an arm or a pair of spaced apart arms. In each arrangement, the arm or arms permits the electric actuator to swing in the event that unequal cable travel is required. In the later arrangement, the arms preferably are substantially parallel and of equal length. The arm or arms further preferably extend substantially orthogonal to the direction of cable pull.

If a pair of arms are provided, they preferably are fixed to both the actuator and the vehicle rigidly, so that the arms flex to pivot when shifting

movement of the actuator is required and the flexing movement is generally in the direction of cable pull. For this, the arms preferably flex in substantially one plane only and can therefore be formed substantially plate-like, so having a depth much greater than the width. In this arrangement, the arms are constructed to resist flexing other than in the direction of cable pull so that movement of the actuator is in the general direction of cable pull only.

The arms may be formed integrally with the actuator particularly if the actuator has a housing of moulded plastic and the arms are moulded depending from the housing. The arms could alternatively be separately connected to the actuator, and may for example, be formed of metal plate and fixed by suitable fixing means. The length of the arms can be arranged as suitable to mount the actuator to relevant support points of the vehicle. The length preferably is relatively short, say about equal to the depth, although it can be longer or shorter as required. In either case, the materials employed can be arranged for flexing as required.

The advantage of rigid fixing and flexing of the arms, is that the arms bias the actuator to return to its zero or datum point. Thus, no further biasing means are required. However, it is possible to employ arms which do not flex and to mount these for pivoting movement, say by hinge connections at each of the actuator and the vehicle, but suitable biasing means are then required to return the actuator to the zero or datum point. (Please confirm this as correct).

Alternatively, a combination of hinged and flexing movement may be employed. This may be achieved by a flexible connection made by the arms with the actuator and by a hinged connection made by the arms and the vehicle support. In fact, if a pair of arms is employed, then only one of the four attachment points needs to be rigid to cause one of the arms to flex, and to therefore cause the above described return travel.

The shifting movement of the electric actuator in most cases is expected to be in the order of only several millimetres at most and in general, about 2 to 3mm. In the mounting arrangement in which the arms pivot or flex, the actuator will move in an arc, but it will be appreciated that the small amount of movement involved will not result in a significant change in the angle of cables extending between the actuator and the brake assemblies. Indeed the change in angle in most cases will be negligible.

It will be appreciated that the arms do not react any additional load if the cable travel of each of the cables is equal. In that circumstance, the actuator is not required to shift and the arms therefore are subject to normal loading, such as torque loading when the actuator applies a cable pull. The arms can be arranged to react in tension or compression, by the direction from which they extend from the actuator. For example, if the arms each extend in the same direction from the actuator, then a shift of the actuator in one direction (transverse to the extent of the arms) will result in one of the arms being in tension, while the other arm is in compression. On the other hand, if the arms extend in opposite directions they respectively will be subject to tensile and compressive loading depending on the direction the actuator shifts.

The dimensions of the arms can vary to suit the application requirements. Also, the positioning and extension of the arms can also vary. What is required however, is that the axes about which the arms pivot are required to be substantially parallel and the arms should extend substantially orthogonal to the direction of cable pull.

The electric actuator may alternatively be mounted on a single arm and that arm may be fixed to the vehicle and the actuator in a similar manner to that of the pair of arms discussed above. Thus, the arm maybe rigidly fixed to a support point of the vehicle and may extend therefrom to a rigid fixing to the actuator, so that movement of the actuator requires flexing of the arm. The arm may therefore be constructed to flex substantially in one plane only and accordingly can be formed plate-like, having a depth much greater than its width. The single arm may have characteristics similar to one of the pair of arms discussed above.

Alternatively, the single arm may be hingedly attached to either or both of the actuator and the vehicle support point. In one arrangement, one of the arm attachments is rigid and the other is hinged. In each case of use of a single arm, the points of attachment to the actuator and the vehicle support point must permit movement of the actuator as necessary in either direction of cable pull.

A single arm arrangement which is fixedly attached to the vehicle support point, will return to its zero or datum point upon return of the cables to a brake off or released condition. That is because the fixed attachment requires the arm to resiliently flex to permit movement of the actuator in the direction of cable

pull. Advantageously, the return movement is automatic when the cable pull is released, so that additional means to facilitate return are not required. If each of the attachments is a hinged attachment, then biasing means of any suitable kind will be required.

A further alternative arrangement for mounting an electric actuator employs a pair of arms which extend from the actuator into connection with the vehicle along substantially the same axis and the axis extends traverse to the direction of cable pull. In this arrangement, the single arm of the above arrangement may be considered as being formed in two parts, preferably axially separated along the axis of connection to the vehicle. The forms of attachment between the pair of arms, the actuator and the vehicle can be fixed or hinged as above described, with biasing means for returning the actuator to the zero or datum point being employed as necessary.

An assembly according to the invention is preferably operable to permit the brakes to be released in the event that the actuator fails, say by a power or component failure, or in an emergency when the brakes cannot be released. This can be achieved in one of the above arrangement, in which the attachment to the vehicle is a hinged attachment, by removing the hinged post of the or each arm and thereafter manipulating the actuator relative to the cable or cables to release the cable tension sufficiently to release the brakes. This procedure can also be adopted if the attachment is rigid, but includes a pin or bolt or the like for rigid attachment.

The assembly preferably is arranged so that the actuator can be shifted to return or partially return from its moved or displaced position (if indeed that has occurred). This is because the stored energy in the resiliently flexed arms, or in the biasing means and the increased tension in the cables may cause the actuator to suddenly release, which may be dangerous to the person or persons involved. Return of the actuator will have the effect of reducing tension in the or each cable and should release at least one of the brake assemblies otherwise applied. With the actuator shifted from its moved or displaced position, the hinge posts or bolts may then be fully removed if further cable tension reduction is required.

The attached drawings show example embodiments of the invention of the foregoing kind. The particularity of those drawings and the associated

description does not supersede the generality of the preceding broad description of the invention.

Figures 1 to 3 show different embodiments of an electric brake actuator assembly according to the invention.

Referring to Figure 1, an electric brake actuator assembly 10 is shown. The assembly 10 includes an electric drive motor 11 which drives a rotatable member 12. The motor 11 drives the rotatable member 12 through a gearbox which is disposed within a housing 13. The rotatable member 12 has been developed by applicant and has a unique construction inasmuch as it is arranged for co-operation with a single, continuous brake cable (not shown), which is connected at each end to a brake assembly associated with each of the rear wheels of a vehicle and which is threaded through the rotatable member 12. The arrows A represent the direction of cable extent from the rotatable member 12 and it will be appreciated that the cable extends through the central channel 14 of the rotatable member 12 in a "S' or "Z" configuration.

The configuration of the rotatable member 12 is not intended to be restrictive on the present invention, although the invention has been developed with that particular configuration and the overall actuator in mind. The present invention however is equally applicable to electric actuators that connect to separate cables rather than a single continuous cable. For example, Figure 1a shows an alternative rotatable member 12', that is rotatable about the axis Ax by suitable electric drive means, and which includes a pair of cables 19 separately connected to opposite ends of the member 12'.

Returning to Figure 1, rotation of the rotatable member 12 in an anti-clockwise direction applies a pull on the brake cable to apply each of the brake assemblies to which the cable is connected. Rotation of the rotatable member 12 in an opposite and clockwise direction, serves to unwind or relax the cable and thereby release the brake assemblies.

The arrangement of the assembly 10 relative to the brake cable and the brake assemblies, ideally is such that an equal cable pull will be applied to the cable sections extending in each direction from the rotatable member 12 and the cable travel caused by that pull will properly apply each brake assembly for secure braking of the vehicle. However, in circumstances described above, when one of the brake assemblies requires greater cable travel than the other,

the assembly includes flexible arms 15 and 16 which are formed integrally with the housing 13 and which extend substantially parallel to one another but in opposite directions and in planes substantially orthogonal to the direction A of cable pull.

The flexible arms 15 and 16 are operable to permit the rotatable member 12, the motor 11 and housing 13, to shift in the direction of cable pull, away from the brake assembly for which further cable travel is required for proper brake assembly application. As will be apparent from Figure 1, the arms 15 and 16 have a depth D of a substantially greater dimension than the thickness T so that the arms can flex in the direction A of cable pull, but are largely constrained against flex in a transverse direction. This is important, because the assembly 10 is required to be firmly held, but with facility for shifting movement as described above. The arrangement shown in Figure 1 achieves this, by only permitting shifting movement of the assembly 10 in the direction A, when uneven cable travel is required. In the absence of an uneven cable travel, the assembly 10 will maintain the rest or home position shown in Figure 1, apart of course from vibrational movement that will occur during vehicle motion.

The arms 15 and 16 also include means for connecting the assembly 10 to support points on the vehicle and these comprise connecting tubes 17 and 18 which are arranged for receipt of a pin (not shown). The support points may for example be formed as part of the floor pan of the vehicle, or as part of the differential, or a combination of both. The pin connection preferably is rigid, so that the arms are caused to flex about the pin connection, rather than to hingedly pivot, although this latter arrangement could be employed if required.

The pin arrangement described above could alternatively take other forms and one or each of the arms 15 and 16 may terminate in a right-angle bend for fastener connection to a support point or for welding thereto. Thus, it will be appreciated that a variety of connecting means could be employed.

An alternative arrangement is shown in Figure 2, in which like parts of Figure 1 are given the same reference numerals, plus 100. In Figure 2, the assembly 100 includes a pair of arms 120 and 121. The arms 120 and 121 are constructed substantially of the same dimensions as that of the arms 15 and 16 of Figure 1, but they extend substantially in the same direction and in substantially parallel planes. As is apparent in Figure 2, the arms 120 and 121

are disposed on either side of the motor 111 and include tubes 122 and 123 for pin connection to a vehicle support in the same manner as the assembly 10 of Figure 1.

Like the Figure 1 arrangement, the arms 120 and 121 are arranged for flexing in the direction A of cable pull, in the event that unequal cable travel is required. The Figure 2 arrangement is illustrative of how the arms of the assembly can be disposed in different directions and still achieve the required flexing movement when required. The assembly 100 may be employed in vehicles in which the assembly 10 of Figure 1 is inappropriate due to different construction.

Referring to Figure 3, an assembly 200 is shown and again, like parts from Figure 1 are given the same reference numeral, plus 200. This Figure 3 arrangement shows still a further alternative mounting arrangement, which employs the twin arm arrangement of Figures 1 and 2, but in a different relative configuration. In the Figure 3 embodiment, a pair of arms 220 and 221 is provided and each arm extends in the same direction and generally parallel, and generally orthogonal to the direction of cable pull. As with the previous embodiments, the arms 220 and 221 permit shifting movement of the assembly 10 in the direction of cable pull when uneven cable travel is required.

As is apparent from each of Figures 1 to 3, the respective arms are formed integrally with the respective gearbox housings. This is particularly appropriate for moulded arrangements, but it is equally possible for the arms to be formed as a bracket. In Figure 2, the arms 120 and 121 may be separately formed and be connected to a web 124, and the bracket so formed comprising the arms and web, is sandwiched between the motor 111 and the gearbox housing 113. Other arrangements could be equally possible.

Figures 5 and 6 show alternative embodiments of the invention. Referring to Figure 5, an assembly 300 is shown including a motor 311, a rotatable member 312 and a housing 313. The rotatable member 312 is of a similar form to the rotatable members of Figures 1 to 3 and includes a channel 314 and cable which extends through the channel 314 and in opposite directions as indicated by the cable arrows A.

The mounting arrangement of the assembly 300 includes a pair of arms 320 and 321, which are disposed at 90° to the arms shown in Figures 1 to 3 and

which extend from the actuator for mounting about a common axis defined by a post 322. The actuator assembly therefore can be displaced about the axis of the post 322 as required when unequal cable pull is necessary.

It will be appreciated that in the Figure 5 embodiment, the arms 320 and 321 are not arranged for flexing in the direction of cable pull. Also, the arms have a thickness so as to substantially prevent flexing in the broad plane thereof, as such flexing movement in that plane is not desirable.

The arms 320 and 321 may be fixed against axial movement relative to the post 322, such as by a step support in the post, or by circlip support, or by other suitable means. The arms however are permitted rotational movement about the post 322 for relevant actuator movement.

Referring to Figure 6, an assembly 400 is shown including an electric actuator of the same kind shown in Figure 5. The mounting arrangement for the assembly 400 includes a single arm 420, which is fixed at one end to the electric actuator and at the other end is formed as a tube 421 for fixing to a vehicle support point in the same manner as the arms of Figures 1 to 3. The arm 420 is arranged for flexing in the direction of cable pull to allow the actuator movement as required. In this embodiment, the arm can be fixed rigidly at each end to the actuator and the vehicle support point, or it can be hingedly fixed at each end. Alternatively, one end may be hinged and the other rigidly fixed.

To promote flexing movement, grooves, parallel to the axis of the tube 421 may be applied to the arm 420. Any number of grooves may be applied depending on the stiffness of the arm 420 and the required degree of flexibility. In a preferred arrangement, grooves are applied to each side of the arm directly opposite each other.

Figure 7 shows an arrangement which permits controlled return movement of the actuator from a displaced position through uneven cable travel. Controlled return is desirable in the event that the electric actuator assembly fails and must be released, because without controlled release in those circumstances, there may be a sudden release of the cable tension, which could be dangerous to the personnel involved.

The arrangement of Figure 7 shows one end section of a typical arm 30 of the kind depicted in Figures 1 to 3 and 6, having a tube end 31 for mounting to a vehicle support point. An eccentric bush 22 includes a bush part 33, and a

transverse lever 34. The bush part 33 is received within the opening 35 of the tube 31, while the lever 34 is formed with an inverted channel 36 to engage about the upper edge 37 of the arm 30.

The bush part 33 includes an eccentric opening 38 for receipt of a bolt 39. In an assembled condition, the bolt extends through the eccentric opening 38 for threaded engagement in the eccentric opening 40 of the vehicle support point 41. The arrangement is such that, with the arm 30 in a flexed condition and the electric actuator having failed in a brake on condition, the bolt 39 can be slightly loosened to lift the lever 34 from channel engagement with the upper edge 37 of the arm 30, and the bush 32 can be rotated by the lever 34 about its eccentric axis. The tube 31 and the arm 30 will move eccentrically with the bush 32 to shift the actuator back to or toward its zero or displaced position, so relieving some or all of the stored energy in the flexed arm and reducing cable tension. The or each bolt (depending on the number of arms employed) can then be removed fully for complete removal of the actuator under safer conditions.

Each of the arrangements of Figures 1 to 6 lend themselves to electronic monitoring of actuation characteristics. Micro switches can for example, be fitted to the arms of the respective arrangements to monitor the amount of shifting movement the assemblies undergo. Excessive shifting movement may indicate wear of the brake shoes, or deterioration of other parts of the overall braking system. The electric nature of the assembly can be used to send an alert signal to the driver, so that the driver can take remedial steps as required.

The invention described herein is susceptible to variations, modifications and/or additions other than those specifically described and it is to be understood that the invention includes all such variations, modifications and/or additions which fall within the spirit and scope of the above description.

DATED: 14 February 2002

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Fig 1

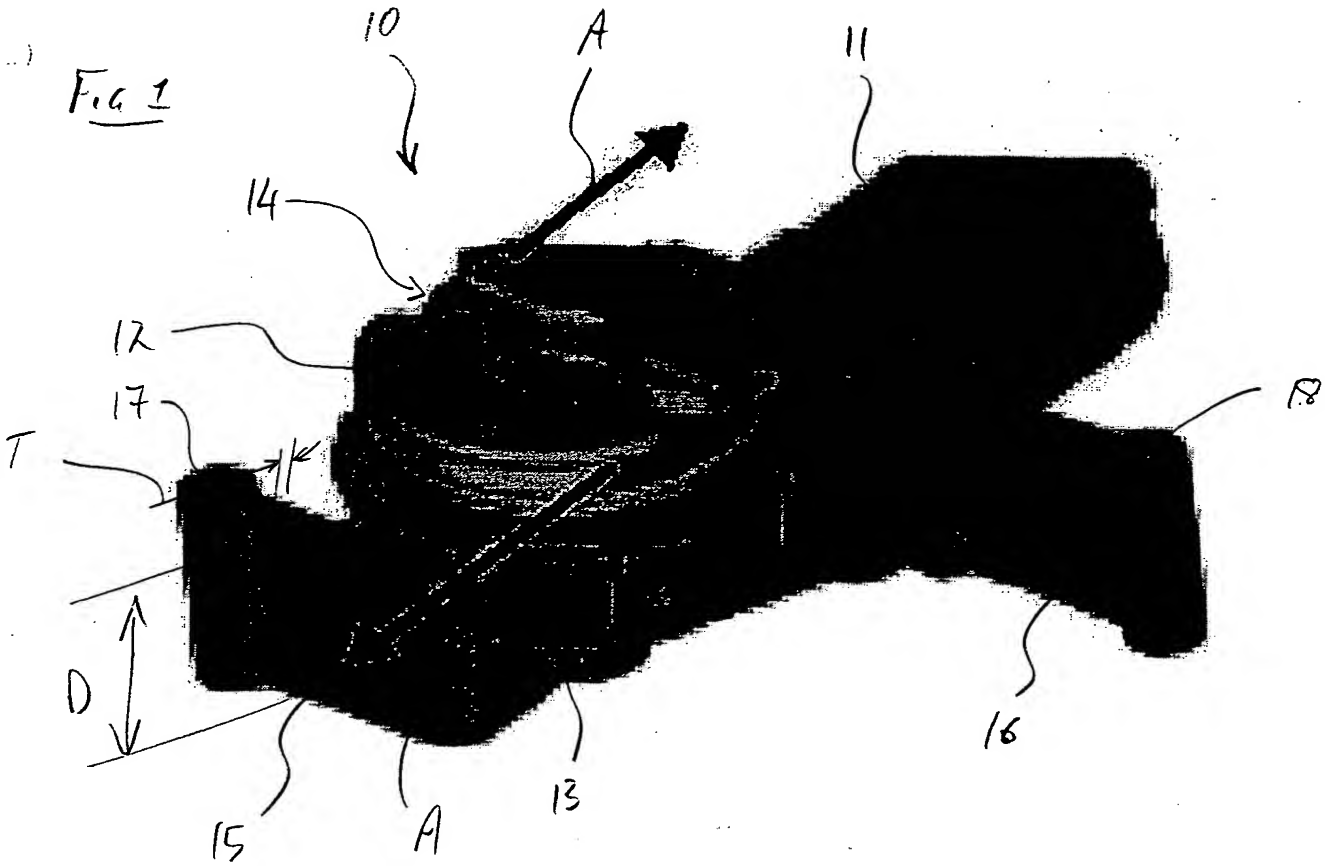

Fig 1a

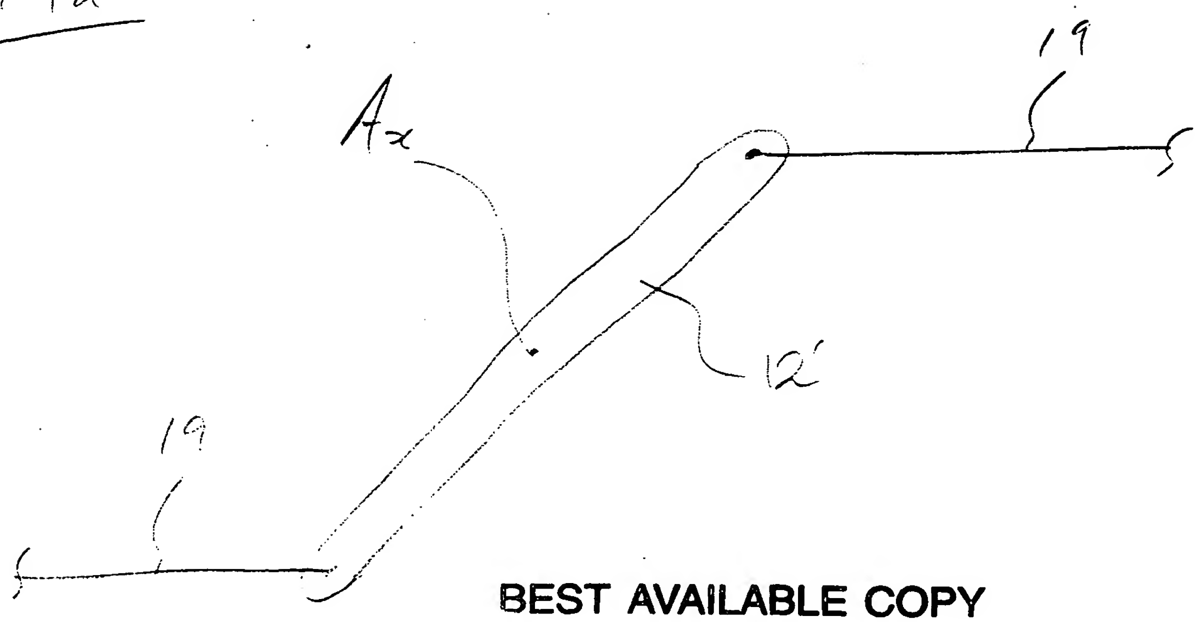

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Fig 2

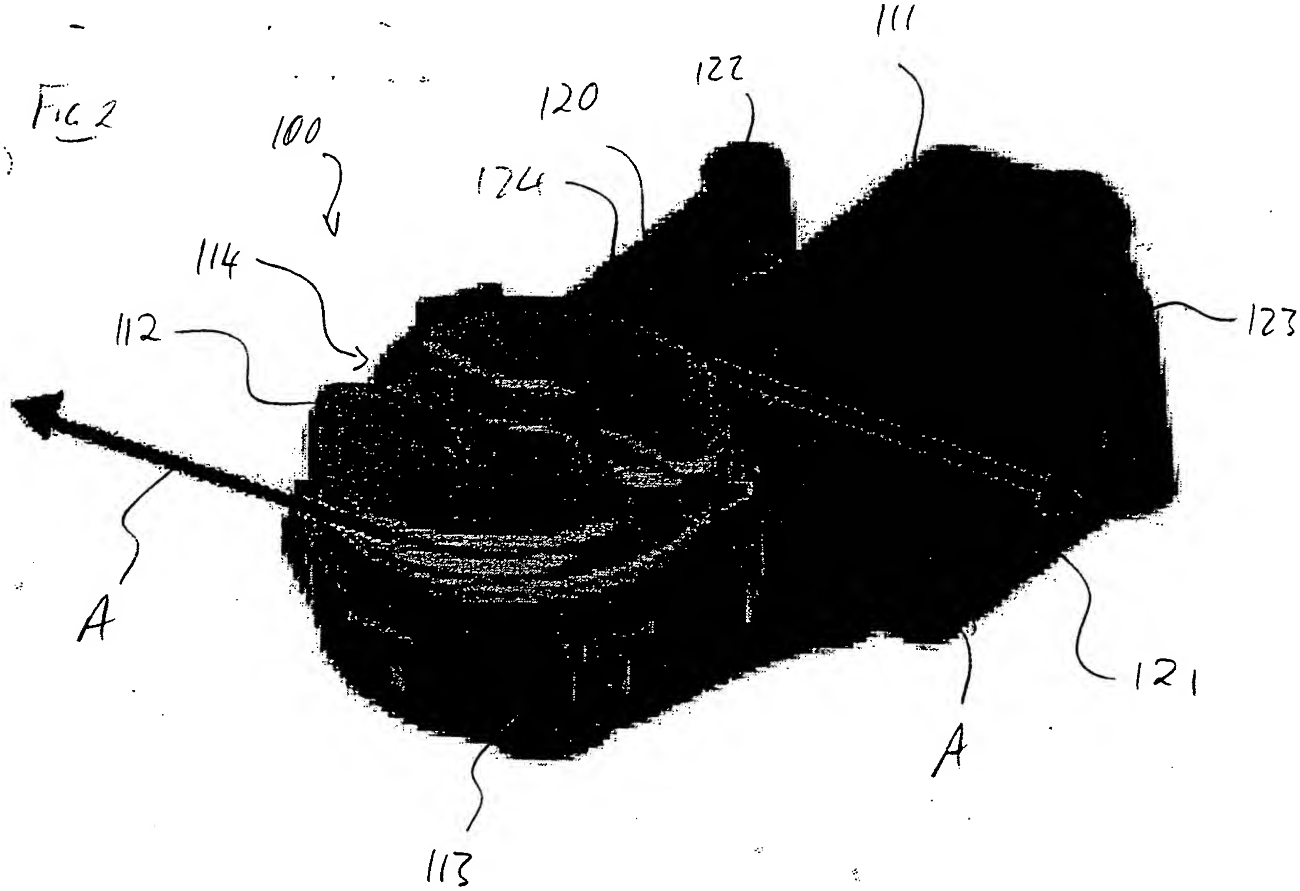

Fig 3

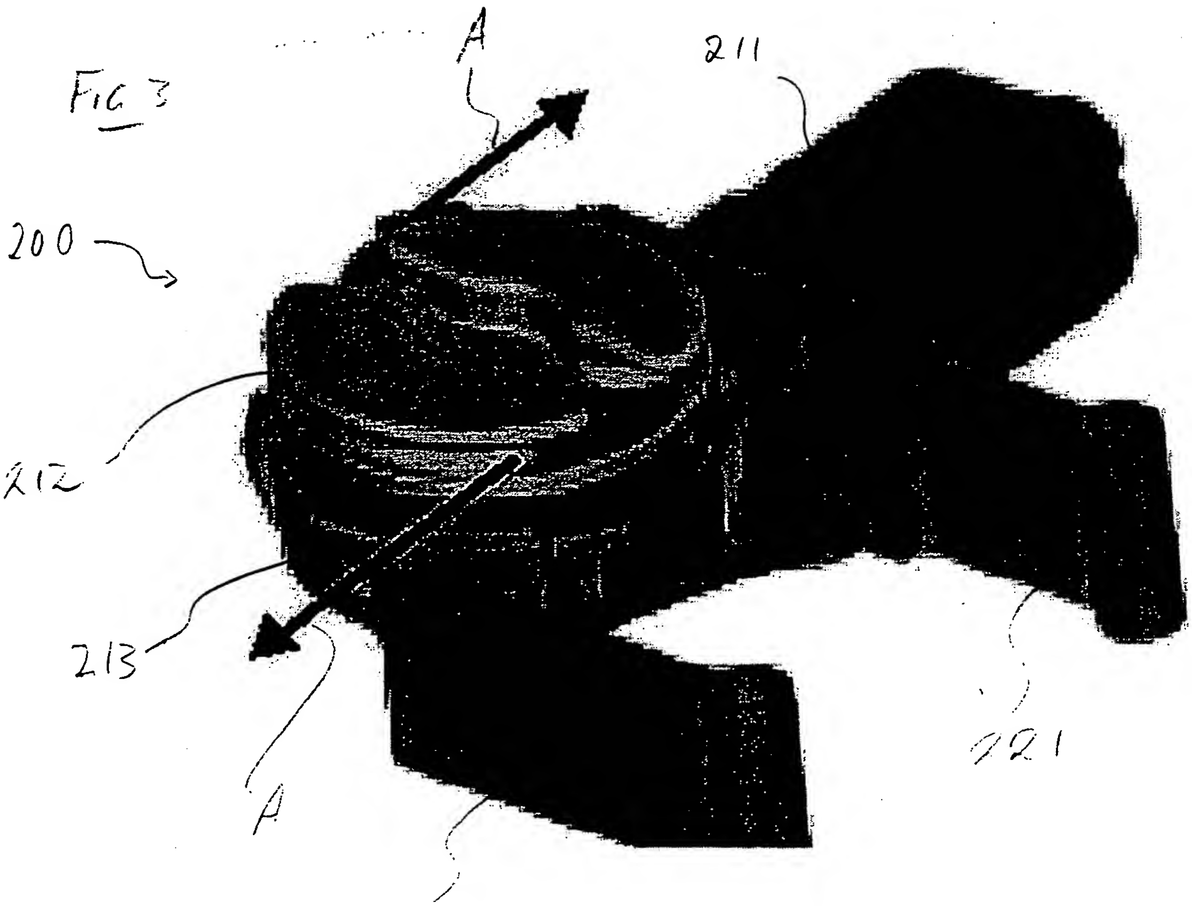

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FIG 5

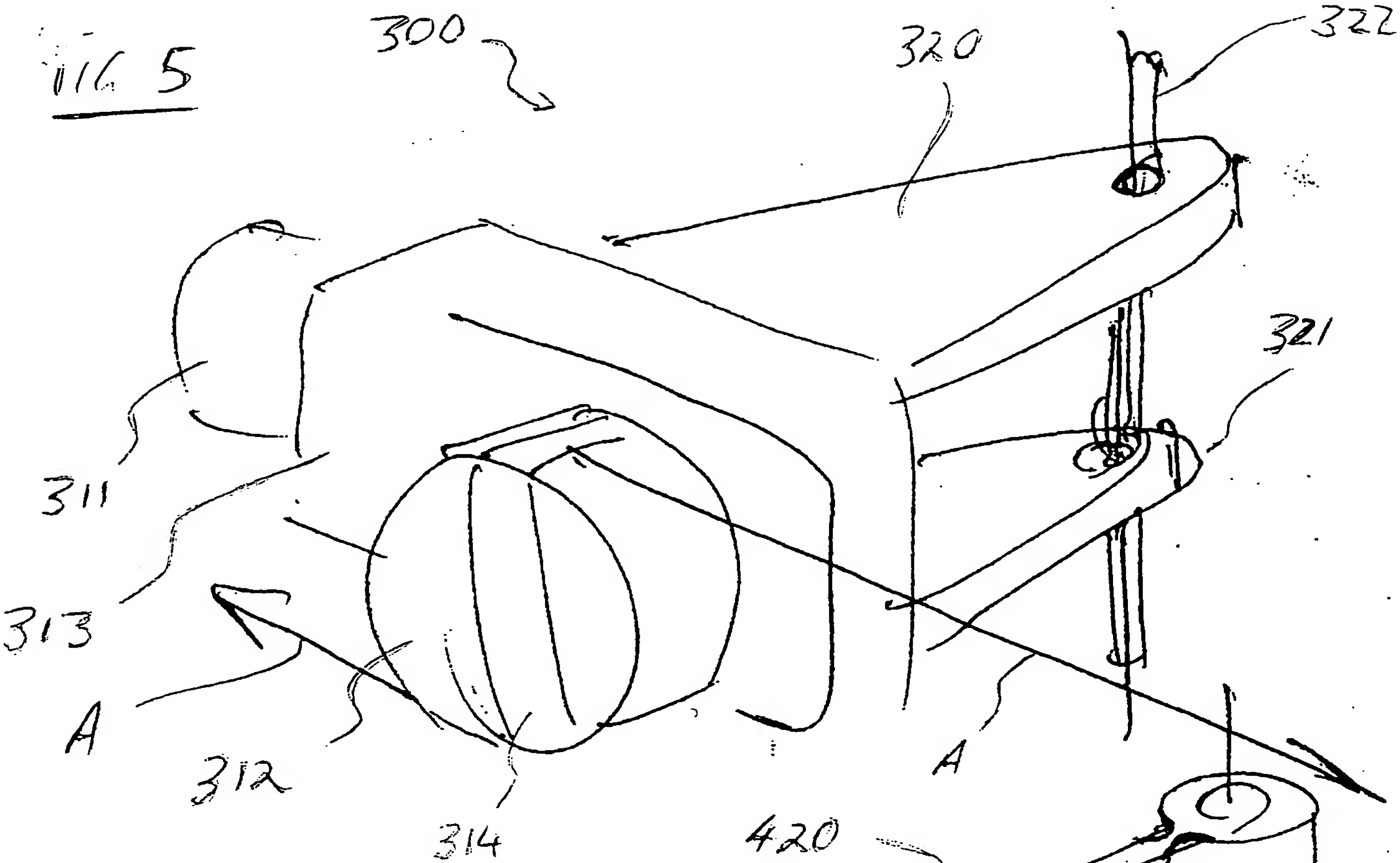


FIG 6

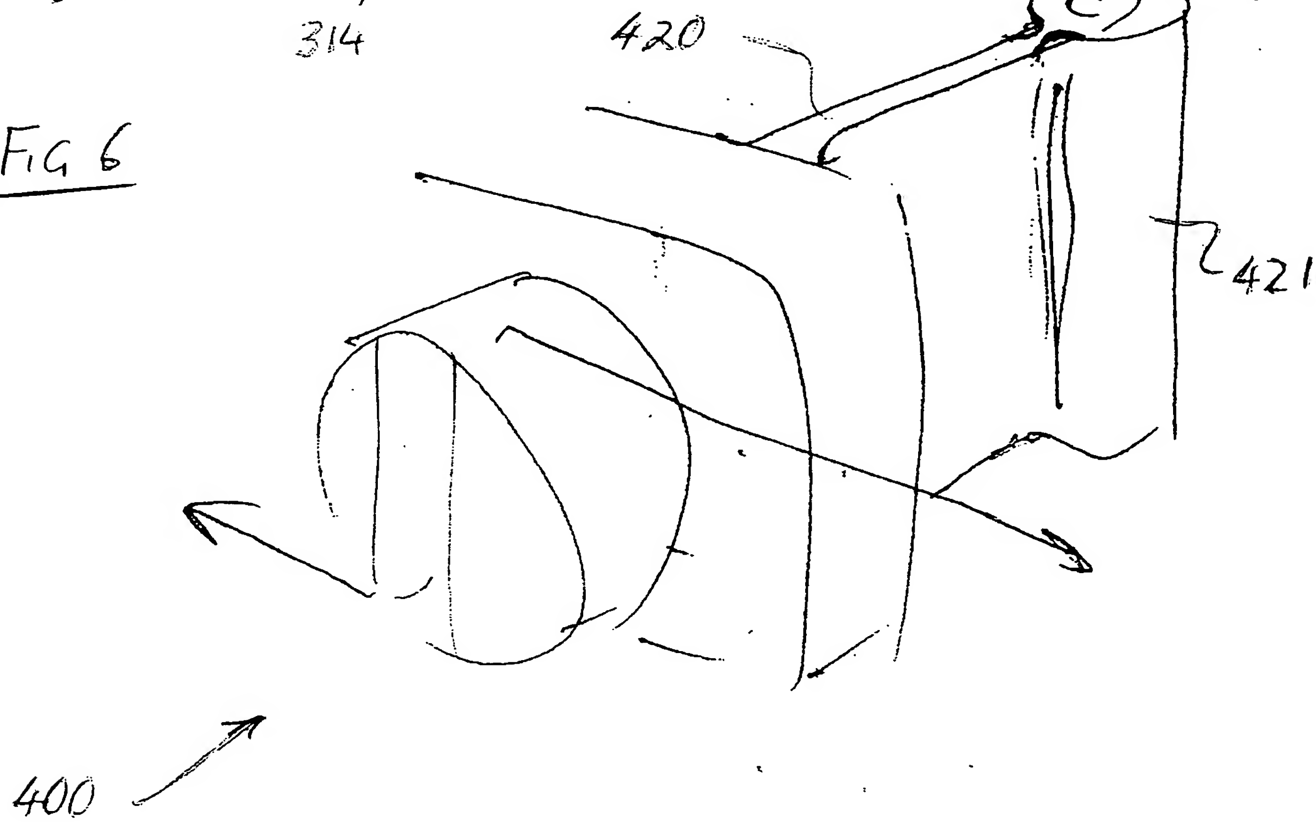
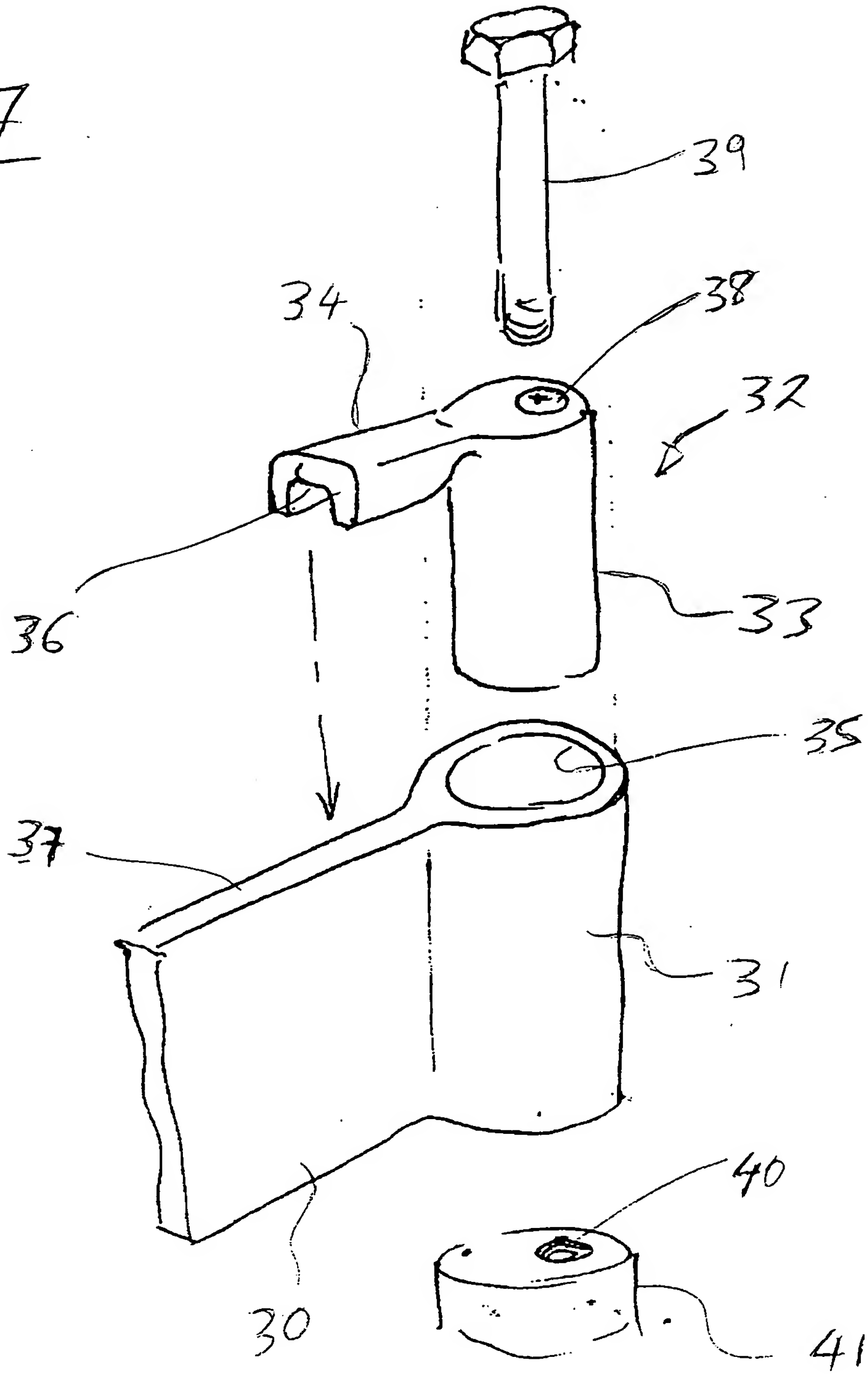


FIG 7



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